# SYSTEMS AND METHODS FOR USING CODE SPACE IN SPREAD-SPECTRUM COMMUNICATIONS

## Claim of Priority under 35 U.S.C. §119

[0001]     The present Application for Patent claims priority to Provisional Application No. 60/452,790 entitled "Method and Apparatus for a Reverse Link Communication in a Communication System" filed March 6, 2003, and Provisional Application No. 60/470,770 entitled "Outer-Loop Power Control for Rel. D" filed May 14, 2003, and are assigned to the assignee hereof and hereby expressly incorporated by reference herein.

## BACKGROUND

### Field

[0002]     The present invention relates generally to telecommunications systems, and more specifically to systems and methods for using direct-sequence codes to spread data over a broad frequency spectrum.

### Background

[0003]     Wireless communication technologies are rapidly advancing, and wireless communication systems are utilized to provide a larger and larger portion of the communications capacity that is currently available to users.  This is true despite the additional technological impediments that are faced in implementing a wireless communication system, as compared to a wireline system.

[0004]     One type of wireless communication system comprises a cellular CDMA (code division multiple access) system that is configured to support voice and data communications.  This system may have multiple base stations that communicate via wireless channels with multiple mobile stations.  (The base stations are also typically coupled via wireline networks to various other systems, such as a public switched telephone network.)  Each base station communicates with a set of mobile stations that are within a sector corresponding to the base station.

[0005]     CDMA refers generally to a form of direct-sequence spread-spectrum communication.  Spread-spectrum communication techniques are generally characterized by several features.  One of these features is the fact that the spread-spectrum signal occupies much greater bandwidth than the minimum bandwidth that is

actually necessary to send the transmitted data. The use of greater bandwidth provides a number of benefits, including greater immunity to interference and tolerance of access by multiple users. Another of the characterizing features is the fact that the spreading of the signal over greater bandwidth is accomplished by means of a spreading code that is independent of the data being transmitted. Another characterizing feature is the fact that the spread-spectrum receiver synchronizes itself with the spreading code in order to recover the transmitted data. The use of independent candidates and synchronous reception by receivers allows multiple users to utilize the system (and the same bandwidth) at the same time.

[0006]     CDMA can be used to transmit various types of data, including digitized voice data, ISDN channels, modem data, and the like. This data is typically transmitted on one or more traffic channels and these traffic channels are combined and transmitted as a single CDMA channel. The traffic channels are typically selected to be orthogonal to each other so that interference from the other traffic channels is minimized. The steps involved in the transmission of a CDMA channel consist generally of error-control coding, interleaving, and modulating the data of each traffic channel, spreading each traffic channel by a code that produces orthogonal sequences of code channel symbols, combining the code channel symbols of the different traffic channels, covering the combined code channel symbols with a pseudorandom code at the chip rate, and filtering, amplifying, and transmitting the signal at the CDMA carrier frequency. Receiving the CDMA channel transmission consists generally of receiving and amplifying the signal, mixing the received signal with a local carrier in order to recover the spread-spectrum signal, generating a pseudorandom code identical to that used in transmission, correlating the signal with the pseudorandom code in order to extract the combined code channel symbols, correlating the sequence of combined code channel symbols with the orthogonal code for each traffic channel, and demodulating, deinterleaving, and error-control-decoding each traffic channel.

[0007]     In one type of CDMA system, referred to as cdma2000, the particular codes that are utilized to spread the traffic channels comprise sequences that are known as Walsh codes. Walsh codes are useful in CDMA systems because, for example, these codes are orthogonal and therefore minimize interference between the other traffic channels from that user. The Walsh codes spread the sequences of modulated symbols on the traffic channels to obtain sequences of modulated symbols at up to the chip rate. The current

cdma2000 system with a chip rate of 1,228,800 chips per second uses Walsh codes of $2^n$ symbols where $n = 2$ to 7. A Walsh code of length $2^n$ uses a fraction $1/2^n$ of the total available Walsh space. For example, a length-4 Walsh code uses one fourth of the total Walsh space and all of the longer length Walsh codes derived from that length-4 Walsh code cannot be used to provide orthogonal sequences. Low-rate traffic channels with low modulation symbol rates can use long Walsh codes that only use a small fraction of the Walsh space without exceeding the maximum spread modulation symbol rate of 1,228,800 symbols per second. However, with high traffic channel data rates, short Walsh codes that use a large fraction of the Walsh space must be used. To obtain the best possible performance with high traffic channel data rates, it is important to use the Walsh space efficiently. The low-rate reverse link traffic channels that are currently defined for cdma2000 only utilize about one fourth of the available Walsh space and the Walsh space that they use is all derived from the same length-4 Walsh code. The cdma2000 system uses the remaining three fourths of the Walsh space for typically high-rate traffic channels. However, the cdma2000 system doesn't make the best use of this three fourths of the Walsh space at its highest data rates. When even higher data rates are used, there is an even more important need in the art for systems and methods for making maximum use of the remaining three fourths of the Walsh space, so that the additional Walsh space can be efficiently utilized to achieve the best possible system performance. in This is true for cdma2000 systems, as well as for other types of wireless spread spectrum communication systems that use other types of codes.

[0008]    A problem with efficiently using the available unused Walsh space is that the Walsh codes only use fractions of $1/2^n$ of Walsh space. So an approach for using three fourths of the Walsh space must be determined. One approach is to just use half of the Walsh space with a length-2 Walsh code. However, this would result is a lower data rate or a higher error-control code rate for the code channel, which is undesirable. Another approach would be to multiplex the high data rate traffic channel onto three length-4 Walsh codes. However, this results in a higher than necessary peak-to-average power ratio for the resulting Walsh spread traffic channel.

## SUMMARY

[0009]    Embodiments disclosed herein address the above stated needs by using a minimum number of different-length Walsh codes to utilize the maximum available

Walsh space. By using fewer Walsh codes to spread the modulation symbols of the code channel, the peak-to-average power ratio of the traffic channel is improved, thereby improving the performance of the system.

[0010]     Generally speaking, the invention comprises systems and methods for improving the performance of direct-sequence spread-spectrum communication systems. In one embodiment, a system uses Walsh codes to spread traffic channel data over a broad communication spectrum. The system comprises a CDMA communication channel with one or more traffic channels where the traffic channels utilize Walsh codes and corresponding portions of the available Walsh space and at least one of the traffic channels utilizes two or more different-length Walsh codes. The portions of the traffic channel data covered by the different Walsh codes are then combined and transmitted via the same CDMA communication channel.

[0011]     One embodiment of the invention comprises a mobile station for use in a wireless communication system, wherein the mobile station is configured to transmit data over one or more traffic channels, including a traffic channel that utilizes at least two different-length Walsh codes. Data to be transmitted by the mobile station is processed to generate symbols, which are then demultiplexed into multiple symbol streams. The mobile station then spreads each of the symbol streams with a different Walsh code, adjusts the powers of the sequences so that the symbols on each of the sequences of any particular traffic channel have the same transmitted energy, and combines the covered symbols of all the traffic channels into a single data stream. The mobile station then transmits the data stream to a base station.

[0012]     An alternative embodiment of the invention comprises a base station that is configured to receive a signal corresponding to a CDMA channel that uses multiple, different-length Walsh codes to spread the data for at least one of its traffic channels. The base station demultiplexes the signal into multiple streams of signals, each of which is despread with a different Walsh code. The different streams corresponding to each traffic channel are then combined to form a single symbol stream. The remainder of the receive process is performed in a conventional manner.

[0013]     Numerous other embodiments are also possible.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0014]     FIG. 1 is a diagram illustrating the structure of an exemplary wireless communications system in accordance with one embodiment;

[0015]     FIG. 2 is a functional block diagram illustrating the basic structural components of a wireless transceiver system in accordance with one embodiment;

[0016]     FIG. 3 is a diagram illustrating multiple channels between the mobile station and base station in accordance with one embodiment;

[0017]     FIG. 4 is a functional block diagram illustrating the structure of a reverse-link enhanced supplemental channel (R-ESCH) for an encoder packet size of 4632, 6168, 9240, 12312, or 15384 bits in accordance with one embodiment; and

[0018]     FIG. 5 is a Walsh tree illustrating the relationship of different Walsh codes (corresponding to different portions of the available Walsh space) in accordance with one embodiment.

## DETAILED DESCRIPTION

[0019]     One or more embodiments of the invention are described below. It should be noted that these and any other embodiments described below are exemplary and are intended to be illustrative of the invention rather than limiting.

[0020]     As described herein, various embodiments of the invention comprise systems and methods for using direct-sequence codes to spread data over a broad frequency spectrum. Spread-spectrum communication systems use various mechanisms for spreading data over a broader bandwidth spectrum than is strictly necessary to send the data in order to improve the performance of the systems. CDMA (Code Division Multiple Access) communication systems use a direct-sequence mechanism to spread the bandwidth of the data signal to be transmitted. This mechanism utilizes pseudo-random codes that are combined with the data to generate a higher frequency signal. The subset of CDMA systems that are encompassed by the IS-2000 standard (also referred to as cdma2000 systems) use Walsh codes to spread the bandwidth of the data signal.

[0021]     The low-rate reverse link traffic channels that were implemented in earlier CDMA communication systems (particularly in previous Revisions/Releases of the IS-2000 standard) used specific subsets of the available Walsh space. These subsets of the available Walsh space occupy about one quarter of the total Walsh space. More

specifically, these codes occupy the $W^4_0$ Walsh space. The $W^m_k$ notation refers to the $k^{th}$ of m Walsh codes of length m where $k = 0$ to $m - 1$ and $m = 2^n$ with $n = 1, 2, 3, \ldots$. When the $W^m_k$ Walsh code is used, the longer length Walsh codes derived from it (its descendants) are no longer available for other traffic channels. For example, the $W^{2m}_k$ and $W^{2m}_{k+m}$ Walsh codes that are directly derived from the $W^m_k$ Walsh code (the first descendants) are not available for other traffic channels when the $W^m_k$ Walsh code is used. Similarly, the $W^{4m}_k$, $W^{4m}_{k+m}$, $W^{4m}_{k+2m}$, and $W^{4m}_{k+3m}$ Walsh codes formed from the first two descendents (i.e., the second descendants) of the $W^m_k$ Walsh code are not available for other traffic channels, and so on. The $W^m_k$ Walsh space is the subset of the Walsh space that is used by the $W^m_k$ Walsh code and its descendants. So when the low-rate traffic channels all use Walsh codes that are descendants of the $W^4_0$ Walsh code, the remaining three quarters of the Walsh space are available for other traffic channels, such as high-rate traffic channels. Various embodiments of the present invention make use of these codes in a way that improves the performance of the respective systems. In particular, for a high-rate traffic channel, rather than using each of the remaining quarters of the Walsh space in connection with a corresponding Walsh code, a quarter of the Walsh space ($W^4_2$) is used in connection with a first new channel, while the remaining half of the Walsh space ($W^2_1$) is used in connection with a second new channel. By using these three quarters of the Walsh space in connection with two new channels formed from different-length Walsh codes instead of from three length-4 channels (one each, corresponding to $W^4_2$, $W^4_1$, and $W^4_3$), the peak-to-average ratio of the resultant CDMA channel is reduced, and the performance of the system is thereby improved.

[0022] It should be noted that, while the invention is described herein primarily with respect to systems that conform to the IS-2000 standard, alternative embodiments may conform to other standards or may make use of pseudo-random spreading codes other than Walsh codes (e.g., M sequences, Gold codes or Kasami codes). It is believed that the present disclosure will be understood by persons of ordinary skill in the art to extend to and enable such alternative embodiments, and such embodiments are intended to be covered by the appended claims.

[0023] A preferred embodiment of the invention is implemented in a wireless communication system that conforms generally to a release of the cdma2000 specification. cdma2000 is a 3rd Generation (3G) wireless communication standard that

is based on the IS-95 standard. The cdma2000 standard has evolved and continues to evolve to continually support new services. The preferred embodiment of the invention is intended to be operable in systems utilizing Release D of the cdma2000 standard, but other embodiments may be implemented in other Releases of cdma2000 or in systems that conform to other standards (e.g., W-CDMA). The embodiments described herein should therefore be considered exemplary, rather than limiting.

**[0024]** Referring to FIGURE 1, a diagram illustrating the structure of an exemplary wireless communications system is shown. As depicted in this figure, system 100 comprises a base station 110 that is configured to communicate with a plurality of mobile stations 120. Mobile stations 120 may, for example, be cellular telephones, personal information managers (PIMs or PDA), or the like that are configured for wireless communication. It should be noted that these devices need not actually be "mobile," but may simply communicate with base station 110 via a wireless link. Base station 110 transmits data to mobile stations 120 via corresponding forward link (FL) channels, while mobile stations 120 transmit data to base station 110 via corresponding reverse link (RL) channels.

**[0025]** It should be noted that, for the purposes of this disclosure, identical items in the figures may be indicated by identical reference numerals followed by a lowercase letter, e.g., 120a, 120b, and so on. The items may be collectively referred to herein simply by the reference numeral.

**[0026]** Base station 110 is also coupled to a switching station 130 via a wireline link. The link to switching station 130 allows base station 110 to communicate with various other system components, such as a data server 140, a public switched telephone network 150, or the Internet 160. It should be noted that the mobile stations and system components in this figure are exemplary and other systems may comprise other types and other combinations of devices.

**[0027]** While, in practice, the specific designs of base station 110 and mobile stations 120 may vary significantly, each serves as a wireless transceiver for communicating over the forward and reverse links. Base station 110 and mobile stations 120 therefore have the same general structure. This structure is illustrated in FIGURE 2.

**[0028]** Referring to FIGURE 2, a functional block diagram illustrating the basic structural components of a wireless transceiver system in accordance with one embodiment is shown. As depicted in this figure, the system comprises a transmit

subsystem 222 and a receive subsystem 224, each of which is coupled to an antenna 226. Transmit subsystem 222 and receive subsystem 224 may be collectively referred to as a transceiver subsystem. Transmit subsystem 222 and receive subsystem 224 access the forward and reverse links through antenna 226. Transmit subsystem 222 and receive subsystem 224 are also coupled to processor 228, which is configured to control transmit and receive subsystems 222 and 224. Memory 230 is coupled to processor 228 to provide working space and local storage for the processor. A data source 232 is coupled to processor 228 to provide data for transmission by the system. Data source 232 may, for example, comprise a microphone or an input from a network device. The data is processed by processor 228 and then forwarded to transmit subsystem 222, which transmits the data via antenna 226. Data received by receive subsystem 224 through antenna 226 is forwarded to processor 228 for processing and then to data output 234 for presentation to a user. Data output 234 may comprise such devices as a speaker, a visual display, or an output to a network device.

[0029]    Persons of skill in the art of the invention will appreciate that the structure depicted in FIGURE 2 is illustrative and that other embodiments may use alternative configurations. For example, processor 228, which may be a general-purpose microprocessor, a digital signal processor (DSP) or a special-purpose processor, may perform some or all of the functions of other components of the transceiver, or any other processing required by the transceiver. The scope of the claims appended hereto are therefore not limited to the particular configurations described herein.

[0030]    Considering the structure of FIGURE 2 as implemented in a mobile station, the components of the system can be viewed as a transceiver subsystem coupled to a processing subsystem, where the transceiver subsystem is responsible for receiving and transmitting data over a wireless channel and the processing subsystem is responsible for preparing and providing data to the transceiver subsystem for transmission and receiving and processing data that it gets from the transceiver subsystem. The transceiver subsystem could be considered to include transmit subsystem 222, receive subsystem 224, and antenna 226. The processing subsystem could be considered to include processor 228, memory 230, data source 232 and data output 234.

[0031]    As indicated above, the communication link between the base station and the mobile station actually comprises various traffic channels. Referring to FIGURE 3, a diagram illustrating multiple traffic channels between the mobile station and the base

station is shown. As depicted in the figure, base station 110 transmits data to mobile station 120 via a set of forward link traffic channels 310. These traffic channels typically include traffic channels over which data is transmitted and traffic channels over which control information is transmitted. Forward link channels 310 may include, for example, a Forward Fundamental Channel (F-FCH) that may be used to transmit low-speed data, a Forward Supplemental Channel (F-SCH) that may be used for high-rate, point-to-point communications, or a Forward High-Speed Broadcast Channel (F-HSBCH) that may be used to broadcast messages to multiple recipients. The channels may also include a Forward Dedicated Control Channel (F-DCCH), a forward broadcast control channel (F-BCCH), or a Forward Paging Channel (F-PCH) that may be used to transmit control information relating to the other traffic channels or to other aspects of the operation of the system.

[0032]    Mobile station 120 transmits data to base station 110 via a set of reverse link traffic channels 320. Again, these traffic channels typically include traffic channels that are used for transmitting data or control information. Mobile station 120 may transmit data back to the base station over such channels as a reverse access channel (R-ACH), an extended reverse access channel (R-EACH), a reverse request channel (R-REQCH), a reverse enhanced supplemental channel (R-ESCH), a reverse dedicated control channel (R-DCCH), a reverse common control channel (R-CCCH), or a reverse rate indicator channel (R-RICH).

[0033]    In one embodiment, the R-ESCH is used to transmit high-rate data from the mobile station to the base station. Data can be transmitted over the R-ESCH at rates up to 1.5384 Mbps. The data is transmitted in 10-ms subpackets. The general structure of the R-ESCH is illustrated in FIGURE 4.

[0034]    Referring to FIGURE 4, a functional block diagram illustrating the structure of the R-ESCH for encoder packet sizes of 4632, 6168, 9240, 12312, or 15384 bits is shown. It should be noted that, in this embodiment, this structure would vary somewhat when used in conjunction with other packet sizes. The structure may also vary in its implementation in other embodiments. The structure of FIGURE 4 is merely exemplary of the possible structures. It should also be noted that the functional block diagram of FIGURE 4 is illustrative of a method for processing data for transmission by a mobile station in accordance with one embodiment. It should be noted that the components illustrated in the functional block diagram, as well as the steps of the corresponding

method, may be rearranged in other embodiments without departing from the scope of the invention.

[0035]    As depicted in FIGURE 4, a 16-bit packet CRC is first added in block 410 to the information bits that are to be transmitted. A 6-bit turbo encoder tail allowance is added in block 420, so that the encoder packet now has a size of 4632, 6168, 9240, 12312, or 15384 bits (corresponding to information packet sizes of 4610, 6146, 9218, 12290, or 15362 bits, respectively). Turbo encoding (block 430) and block interleaving (block 440) are then performed on the encoder packet. Symbols are then selected from the interleaved data in block 450, and the resulting symbols are modulated (block 460).

[0036]    The symbols are then covered with the appropriate Walsh codes (block 470). In the embodiment depicted in FIGURE 4, this is accomplished with a series of components comprising a symbol or sequence demultiplexer (block 471), components to cover the symbols with the appropriate Walsh codes (blocks 472 and 473), a power amplifier (block 474), and a chip-level summer (block 475).

[0037]    In the traffic channel depicted by FIGURE 4, demultiplexer 471 converts the single stream of symbols from modulator 460 and produces two separate streams. For the symbol DEMUX embodiment, one of the streams consists of every third symbol and it is processed in block 472 where the symbols are covered with the + + − − Walsh code and the other stream consists of the remainder of the symbols (two-thirds of the total) and they are processed in block 473 where the symbols are covered with the + − Walsh code. For the sequence DEMUX embodiment, one of the streams consists of the first one-third of the input symbols and they are processed in block 472 where the symbols are covered with the + + − − Walsh code and the other stream consists of the last two-thirds of the input symbols and they are processed in block 473 where the symbols are covered with the + − Walsh code. The symbols processed by block 473 are amplified in block 474 to provide a 2x power gain. The two separate symbols streams are then summed at block 475 to multiplex them back into a single stream for transmission.

[0038]    As noted above, processing the data of the R-ESCH in this manner makes use of the entire three-quarters of the Walsh space that was available for the high-rate traffic channel, but only uses two Walsh channels. Those skilled in the art will recognize that the use of two Walsh channels instead of three will reduce the peak-to-average power ratio of the R-ESCH. Because the peak-to-average power ratio is reduced, the mobile

station can operate its power amplifier closer to the saturation point and can thereby gain a range advantage.

[0039]    It should be noted that the processing of data to be transmitted over the R-ESCH as described herein is intended to be exemplary rather than limiting.   While the disclosed techniques can be used to utilize as much Walsh channel resources as possible by multiplexing a single traffic channel over multiple channels that use different-length Walsh codes to minimize the number of required Walsh channels, these techniques can be utilized with other types of channels and resources.   The techniques used in the disclosed embodiments may be used with other channels as well.   Alternative embodiments may implement these techniques in other reverse link channels or in forward link channels, and need not conform to cdma2000 or any other particular standard.

[0040]    As noted above, a particular traffic channel (e.g., R-FCH) conventionally utilizes a single Walsh code.   In such a traffic channel, the symbols can be covered by the appropriate Walsh code in a very straightforward manner. In the channel depicted in FIGURE 4, however, two Walsh channels are used.   Moreover, each of these channels uses different-length Walsh codes ($W^4_2$ and $W^2_1$, in this embodiment).   It is therefore a more complex task to cover the symbols generated within the channel with the appropriate Walsh codes.   Thus, block 470 of the channel in FIGURE 4 must demultiplex the pairs (I and Q) of modulated symbols, cover some of the symbols with length-4 Walsh codes, cover the remainder of the symbols with length-2 Walsh codes, amplify the symbols covered with the length-2 Walsh code, and then recombine all of the covered symbols to produce the signal to be transmitted.

[0041]    As indicated above, the reverse link channel depicted in FIGURE 4 uses both length-4 and length-2 Walsh codes.   The reason for using these Walsh candidates is described with reference to FIGURE 5.   Referring to FIGURE 5, a Walsh tree illustrating the relationship of different Walsh codes (corresponding to different portions of the available Walsh space) is shown.   As depicted in this figure, the Walsh space (all of the possible Walsh codes) can be shown as a tree, with a number of branches, and leaves at the ends of some of the branches.   Each branch of the Walsh tree corresponds to a subset of the possible Walsh codes.   Thus, the top-level node 500 branches into two sets of length-2 codes (nodes 510 and 520, corresponding to codes $W^2_1$ and $W^2_0$, or $+-$ and $++$, respectively).   Similarly, node 520 branches into two sets of length-4 codes

(nodes 530 and 540), node 540 branches into two sets of length-8 codes (nodes 550 and 560), node 550 branches into two sets of length-16 codes (nodes 553 and 557), node 560 branches into two sets of length-16 codes (nodes 563 and 567), and so on.

[0042]    The different Walsh codes corresponding to the different nodes of the Walsh tree are used to ensure that the corresponding channels are orthogonal. Once a particular node on the tree is used, it terminates the tree, and no further branches from that node can be used. For example, the Walsh codes corresponding to node 568 are used for the reverse pilot channel (R-PICH), so there can be no further branches from this node. On the other hand, the Walsh codes corresponding to node 565 are not used for any of the channels, so the tree branches to nodes 564 and 566, and Walsh codes corresponding to these nodes are available for use with the reverse rate indicator channel (R-RICH) and the reverse acknowledgment channel (R-ACKCH), respectively.

[0043]    Most of the top quarter of the Walsh space is used by low-rate legacy traffic channels. These traffic channels and their corresponding Walsh codes and nodes of the Walsh tree of FIGURE 5 are shown in the following table. The reverse enhanced supplemental channel (R-ESCH) uses the three quarters of the Walsh space corresponding to $W^4_2$ and $W^2_1$ (nodes 530 and 510, respectively), while the R-RICH (reverse rate indicator channel) that provides control information for the R-ESCH employs an unused Walsh code ($W^{64}_{48}$) in the already occupied top quarter of the Walsh tree of FIGURE 5.

Table 1 – legacy channels and use of Walsh space

| Channel | Walsh codes | Node in FIGURE 5 |
|---------|-------------|------------------|
| R-FCH | $W^{16}_4$ | 557 |
| R-CQICH | $W^{16}_{12}$ | 553 |
| R-DCCH | $W^{16}_8$ | 563 |
| R-PICH | $W^{32}_0$ | 568 |
| R-ACKCH | $W^{64}_{16}$ | 566 |

[0044]    Conventionally, the covering of the symbols with a Walsh code in a traffic channel would be accomplished by taking the Walsh code that is appropriate for the traffic channel and modulating the symbols with the Walsh code. The resulting data would then be transmitted on the corresponding Walsh channel. Because it is intended

for the R-ESCH in the present embodiment to use Walsh resources corresponding to three quarters of the Walsh space, however, more than a single Walsh channel must be used (no single Walsh channel covers all of the desired Walsh space without also covering the already-used Walsh space). Rather than using the Walsh codes for each of the three available quarters of the Walsh space ($W^4_2$, $W^4_1$, and $W^4_3$), in connection with three corresponding Walsh channels, only two Walsh channels and the corresponding Walsh codes ($W^4_2$ and $W^2_1$) are used. This is somewhat counter intuitive because it might be simpler to implement the use of Walsh codes that are all the same length (i.e., $W^4_n$) instead of different lengths ($W^4_2$ and $W^2_1$). The different length codes used in this embodiment, however, provide improved performance in that the use of fewer channels (two instead of three) results in a lower peak-to-average ratio.

[0045]    The embodiment described utilizes three quarters of the Walsh space to cover the data transmitted over a reverse link data channel. As noted above, this embodiment may be implemented in a mobile station in a wireless communication system. An alternative embodiment may comprise a base station for receiving the data transmitted over the reverse link data channel and decoding the data. The process of decoding the data would essentially follow the reverse of the foregoing channel description. For instance, the received signal would be demultiplexed and decoded using the different-length Walsh codes to generate subpacket symbols, which would then be multiplexed into a single stream of symbols that could be decoded in a relatively conventional manner. The invention therefore includes embodiments that can be implemented with respect to both the transmission and reception of data.

[0046]    Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0047]    Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and

steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[0048]     The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0049]     The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0050]     The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from

the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[0051]     **WHAT IS CLAIMED IS:**